Smart Cities 2018

Abstract:

Will Smart Cities emerge with a common IoT platform for multiple applications? What applications are mature for Smart City IoT, and how many will ship over the next five years? This report answers key questions about what city governments will do with IoT technology, and how the connectivity of various devices will evolve over time.

May 2018

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IoT Special Report:

Smart Cities 2018

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1 EXECUTIVE SUMMARY

Smart Cities are often listed as an exciting area of IoT development, with vast improvements in quality of life for city residents. According to media reports, smart city traffic will flow without stopping, crime will be reduced, and the earth will stop warming up.

We see the market somewhat differently, with a few key applications that are growing successfully but without the nirvana of fully integrated IoT platforms that do “everything”.

This market study lays out a few key applications that will be funded or governed by cities, which have started to grow and which have sizable potential. Street lighting, smart parking, smart waste management, and a few other applications have now been shown to yield a positive return on investment for cities, in both tangible and intangible benefits.

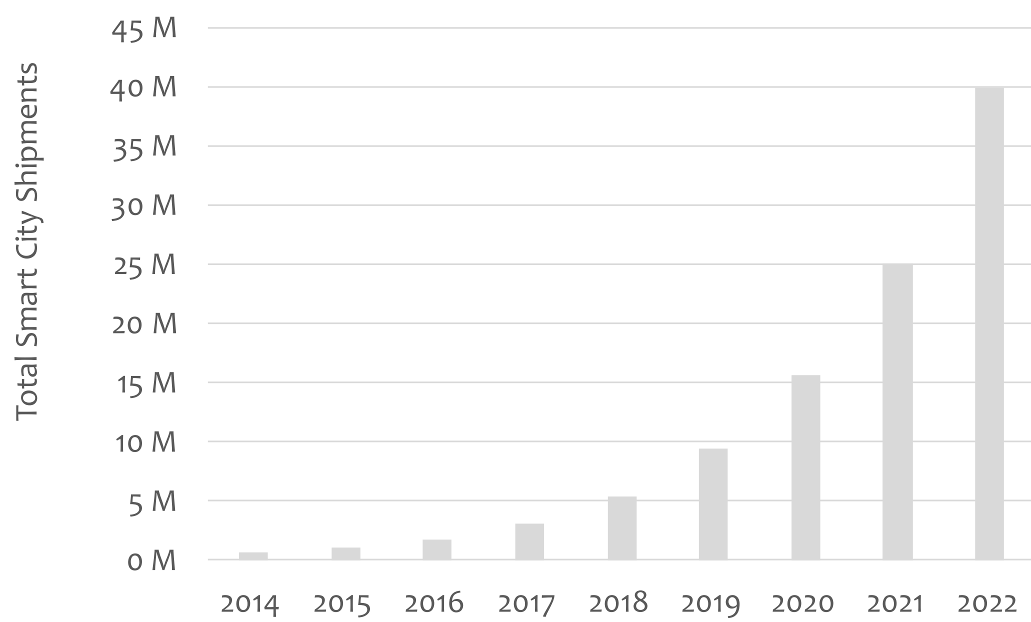

Chart 1: Total Smart City IoT Devices, 2014-2022

Source: Mobile Experts

While some key applications have reached mainstream adoption, some other applications will be adopted slowly over a long time without any integration with the existing IoT networks. Smart traffic control, security/surveillance, and transport management are examples of newer smart city applications that are likely to be implemented separately from the waste bins and streetlights already deployed in the city.

The bottom line is that we see the Smart City area as a healthy contributor to the overall IoT market, with wireless connectivity in many cases. The Smart City market should grow into the tens of millions of devices per year by 2022, with some devices (such as traffic control or transport) requiring high reliability and commanding higher prices. We see this as a growing market—but without enough synergy to justify a common-platform all-inclusive approach.

2 KEY APPLICATIONS

The concept of "smart cities" encompasses a wide variety of different use cases, including applications that primarily serve city staff, as well as applications that serve residents more directly. Mobile Experts classifies applications that are governed directly by city government as "smart city" applications, including a few areas such as Smart Parking which can also include private enterprise implementations.

The key applications covered in this report include:

- Street lighting;
- Smart Parking;
- Smart Waste Disposal;
- Police-related Security/surveillance;
- Public Transport Management;
- Traffic Control; and
- Air Quality Monitoring.

We break out Smart Meters for all utilities (electricity, gas, water, other) in a separate market segment because the Smart Meter market is far more mature than other applications, and utilities are often not associated with city government.

Similarly, IoT devices related to management of the electrical grid or waste water treatment are covered in our Industrial IoT research, as the benefits are not visible to city residents and the business model is a straightforward enterprise sale, not an investment for more generalized public benefits.

SMART STREETLIGHTS:

The wide variety of other Smart City applications normally starts with a discussion about street lighting. Firstly, control of streetlights can reduce energy costs for a city dramatically, with a tangible return on investment that can justify the project without special taxes or other political maneuvers.

Secondly, the smart streetlight is always located at least 4-6 meters above the street, and spaced about 30-50 meters apart. This makes the streetlight platform an ideal location for a wireless hub, with good radio signal quality at almost all locations for most cities in the developed world. In this way, the smart streetlight can become a basis for mesh networking or a backhaul network for other applications in the future.

Figure 1 Installing a smart streetlight

Sources: USAF

Much of the benefit of lighting upgrades can be attributed to the LED lights themselves, which are more energy efficient than old sodium lights. However, the benefits with networked streetlights are clearly greater in terms of crime prevention, safety, and improved control over dimming features or timespan of LED operation. The early installations of networked streetlights so far yield about 10-20% additional energy savings from the networking aspect, not the LED aspect of the upgrade project.

Hundreds of millions of LED streetlight upgrades have been shipped to date, including units connected by unlicensed LPWA technologies, by PLC technology, and through 802.15.4 mesh wireless links. As time goes by, the companies associated with connectivity (such as Telensa, Echelon, Silver Spring, and others) are becoming entrenched by virtue of their ability to format data and manage data in a user interface that is useful for cities. Competing ideas that come into the market are at a disadvantage today because the existing streetlight vendors are starting to make excellent inroads in terms of managing data and using simple commands to control large numbers of streetlights for best efficiency.

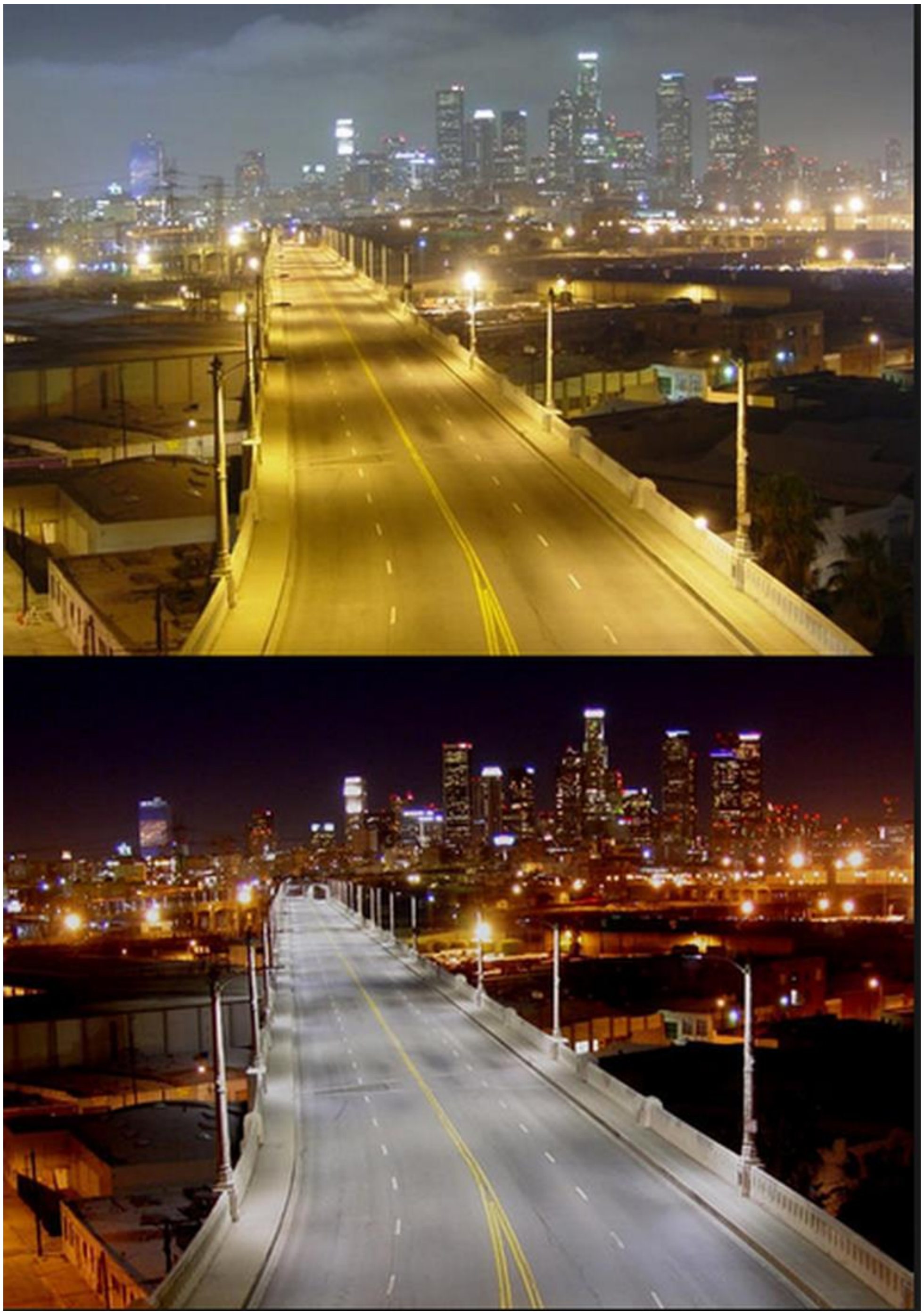

Figure 2   Before – and – After pictures with smart networked streetlights

Sources: City of Los Angeles

The ROI for smart streetlights can be compelling, with payback between five and seven years for a typical project.   With about 320 million streetlights in the world (60 million in the USA), the market is sizable and the initial deployment of about 10 million has only scratched the surface. We estimate that LED upgrades will take place on at least 100 million streetlights by 2025, and at least 1/3 will include IoT connectivity.

SMART PARKING:

Many cities see multiple benefits from improved information about parking availability. There are benefits to drivers of individual cars, as well as collective benefits in terms of reduced traffic congestion.

Vendor research in this area is doubtful, but some traffic experts estimate that up to 30% of urban traffic consists of drivers that are circling to find a parking space. In one more scientific survey of 18,000 drivers, INRIX Research estimated that the average driver in the UK and Germany spends 40 hours annually searching for parking, and in US cities such as New York, Los Angeles, and San Francisco, drivers spend 83 to 107 hours per year searching for parking.

Drivers also overpay for parking, often paying for a longer time than necessary. Underpayment can also be a problem, with fines at a level of several million dollars per year at expired parking meters.

Figure 3 Smart parking module examples (Telensa, Libelium)

Sources: Telensa, Libelium

The ROI for smart parking is not as straightforward as for smart streetlights, because the primary benefit is for the driver, not the city. The city doesn't see a direct benefit in terms of reducing its energy bill. But cities do anticipate a reduction of traffic, especially in key areas. It's possible to construct ROI case studies that show a net savings in road upgrades and other traffic-related costs. Early trials with these concepts have resulted in encouraging comments from the local cities, as well as operators of EV charging stations and local businesses that see benefits for their customers.

Figure 4 Smart parking spaces in Croatia

Sources: Nedap

The radio challenge for smart parking devices can be difficult. In a large concrete parking structure, underneath the steel structure of a car, the RF signal can be severely blocked. In this way, short-range wireless technologies can be difficult to use. Mesh technologies or wide-area IoT technologies with margin in the link budget are necessary to effectively communicate with 100% of the parking sensors.

SMART WASTE DISPOSAL:

One of the classic applications for improving efficiency in city services involves trash. There's no need to pick up trash if the can isn't full….but at the same time, when the trash can is filled, it should be emptied immediately to prevent litter. A few companies have been working on this use case for years already. For example, Bigbelly has deployed smart waste solutions in more than 50 countries so far.

The interesting side benefit of the smart trash can is that it becomes a platform, either for other wireless services such as municipal Wi-Fi/cellular, or for advertising. The city can make a profit on renting the space in each smart trash can, making the ROI for this application higher than almost any other. In addition to the benefits of labor/equipment savings in waste removal, the revenue opportunity results in an ROI measured in weeks or a few months.   This opens up the possibility that the waste bin supplier can provide the bins for free, recouping costs and making profit based on advertising or hosting wireless access points.

Figure 5   Smart waste management solution in New York City

Sources: Bigbelly

POLICE/MUNICIPAL SECURITY SENSORS:

In some cities, crime levels justify the use of video surveillance cameras for key areas, and many cities are now considering the use of "gunshot detection" and other similar systems, using infrastructure throughout the city to help police locate crime more precisely.   These applications are good example of Mobile Edge Computing cases, where wireless infrastructure would be useful, but a computing platform is also used locally. The computing platform is necessary to accomplish tasks such as facial recognition or triangulating on a gunshot sound, then communicating the results to police dispatchers.

Security infrastructure of this type is often considered as a second step. After a city has installed smart streetlights, then they can consider adding features that make use of the wireless infrastructure. For this reason, we see these security solutions as less mature than smart lighting or parking today. This application is more likely to grow as the cities develop more ubiquitous infrastructure, or begin to make more regular use of mobile networks for other applications.

The ROI is clear in terms of reducing crime, or catching criminals---but of course this kind of ROI is not quantified in terms of dollars and cents. Each city will be driven to invest in security infrastructure by local crime conditions and their perceived liability for preventing crime.

Figure 6 Existing police surveillance system in NYC

Sources: Mario Tama

PUBLIC TRANSPORT MANAGEMENT SYSTEMS:

Subway and bus systems historically have relied on human drivers to stay on a fixed timetable. This process often leaves gaps in service, where too few trains or buses are available at peak times—and at the same time, empty vehicles are driven around when demand is light.

Automating the process can allow for more flexibility, adding service during peak times and working with a more flexible timetable. The automation essentially relies on centralized knowledge of the position for each vehicle, as well as information about the number of passengers in waiting areas and on board.

Some transit authorities also want to integrate their payment system with the overall management of the network, using payment information as a way to monitor passengers by location.

The ROI for these applications essentially takes the form of less waiting time for passengers, so it's not easily quantified as a simple financial metric. The revenue from increased adoption of mass transit can show a financial return over the long term, but we believe that the financial considerations are secondary to quality of transit service.

Figure 7 Train control is extremely complex

Sources: ITS-UK Review

Of course, in addition to monitoring and controlling the trains and buses, in most cases the transit authority would like to make use of broadband connectivity as well. This takes two forms:

- Passengers want to use Wi-Fi services on board; and
- Security video cameras on board the vehicle require high capacity wireless links.

In this way, the IoT connectivity for a bus or train is often dependent on other services as well.   To get the project funded, the broadband access and security aspects of the project are necessary.   So a narrowband wireless format may be inadequate for the whole project.

TRAFFIC MANAGEMENT SYSTEMS:

Automobile traffic on the roadways can be even more challenging than train or bus control, due to the sheer numbers of traffic signals in a city.   Los Angeles has an automated traffic surveillance and control (ATSAC) system that controls about 5,000 intersections, with more than 20,000 street sensors.

Figure 8   An advanced traffic control system

Sources: Kimley-Horn

AIR QUALITY MONITORING:

Pollen or particulates in the air can cause health problems, and many cities have started tracking air quality levels, and even setting rules about automobile usage or wood-burning fires based on the anticipated air quality levels.   This application is very unlikely to drive wide deployment of a new network, but many cities are looking at air quality as a secondary application. In other words, once the smart streetlights are installed, they may want to add air quality sensors as well.

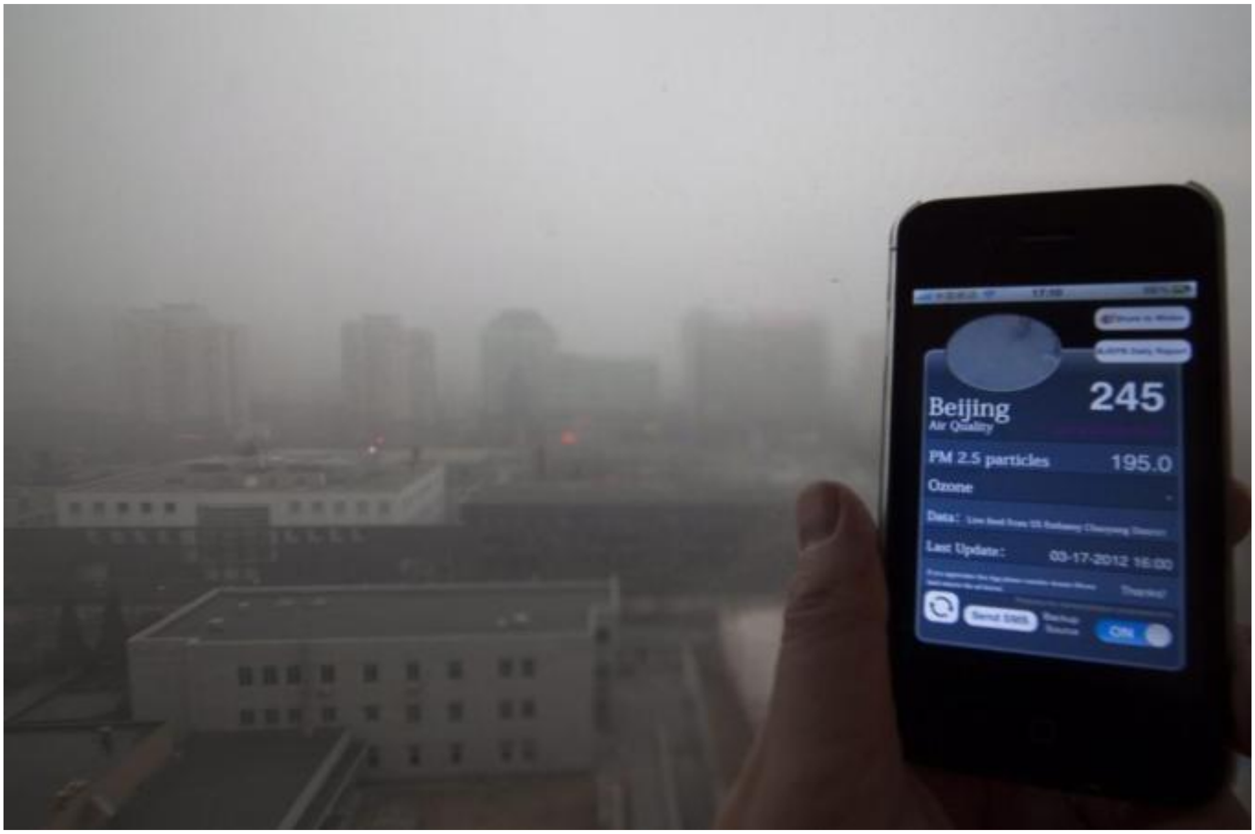

Figure 9   Beijing air quality app making use of air quality sensors

Sources: Al Jazeera

3 MARKET DRIVERS AND CHALLENGES

The impetus for smart cities is a complex mixture of economic and political factors. Economic factors include:

- Energy savings with smart streetlights
- Reduced labor costs from improved information about streetlight maintenance
- Increased capacity for cars in a shopping district (smart parking, traffic control)
- Capital and labor savings with improved waste collection efficiency
- Increased capacity on existing railways through better control

Political factors with less clear economic benefits include:

- Improved safety with streetlights
- Crime prevention
- Environmental benefits of improved garbage truck efficiency
- Improved access to parking
- Improved information about air quality

ECONOMIC FACTORS:

The ROI can be compelling for streetlight replacement, smart trash cans, and improved train controls. That's why these applications are some of the most mature in terms of the number of cities that have implemented solutions.

Here's a quick case study: For 80,000 streetlights in a major American city, the expected cost of a streetlight upgrade is about $460 while an IoT-enabled streetlight costs about $570. The labor savings and further energy improvements related to connectivity can result in about 20% improvement in the cost savings overall, so over the long term the more expensive connected streetlights are a better choice.

The breakeven point in our simple example works out to about 7 years, which is not attractive in some tech markets but it's good enough for a city government that calculates 20-year ROI and 40-year ROI for this kind of project.

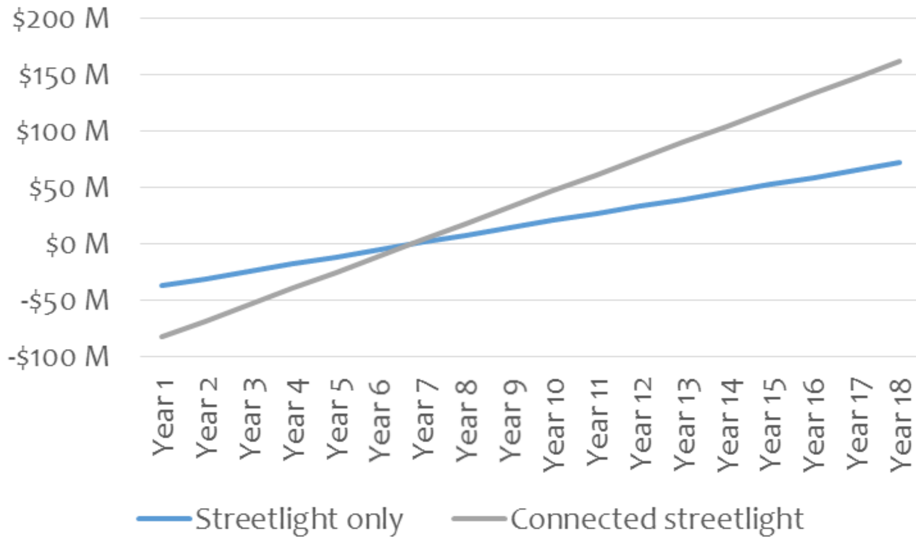

Figure 10 Typical ROI calculation for a connected streetlight project

Sources: Silver Spring, Mobile Experts

Interestingly, some cities do not see the benefits in energy and labor savings. The City of Seattle commissioned a study of smart trash cans in 400 city parks. This study concluded that the Net Present Value of the project was negative; in other words, the cost of the trash cans outweighed the savings. However, this analysis ignored the impact of advertising on the side of the trash can, as well as the potential revenue from leasing space to telecom operators. Considering these factors, the trash can example becomes quite profitable for the city.

These examples lead us to conclude that ROI is not a slam-dunk for most smart-city projects. The payback depends on multiple factors and the pure economics may not be enough to justify the project.

A second important point is that we don't see a strong ROI in forcing multiple smart-city applications into a common platform. Any city that tries to force a single technology platform on multiple devices will run into interminable delays and huge unforeseen costs.

POLITICAL FACTORS:

If the economic story is not compelling, a business would stop and reconsider. However, we see many city politicians charging ahead with smart-city projects anyway---because it's simply good politics. The intangible benefits of crime reduction, improved parking, and helping the environment can be powerful messages for the voters of the city.

While the political value of projects can be a positive, overall our assessment is that city government is mainly a hindrance to development of Smart City projects. The obscure processes for making decisions can make a project difficult to adopt.

Some examples can defy the political barriers. Bigbelly, for example, is very successful at convincing cities to implement smart waste bins because they can offer advertising on the waste bin, creating revenue for the city… or Bigbelly can finance the initial installation, making it a zero-cost transaction for the city. In this way, the political processes can be bypassed and the project can motor ahead quickly.

Streetlight vendors offering LED upgrades have similar ideas about offering incentives or financing in order to simplify the political approval process. The cost savings of an LED upgrade can pay for the upgrades, so it's a matter of distributing the costs differently between the parties in order to make approval quicker. Connectivity for the streetlight is less important in the overall ROI equation, so some projects end up dropping the connectivity element for simplicity.

4 CONNECTIVITY TECHNOLOGY OPTIONS

The connectivity for Smart Cities can include a variety of choices:

1. Ethernet (wires);
2. PLC;
3. Zigbee and other 802.15.4 formats;
4. Wi-Fi;
5. LoRa;
6. Telensa UNB (and other unlicensed LPWA);
7. GSM, 3G, and LTE; and
8. NB-IoT.

ETHERNET

Ethernet is a communications protocol that takes multiple physical forms, including twisted-pair cabling, fiberoptics, and point-to-point microwave links, among others. In the context of Smart Cities systems, Ethernet is most likely to be used for streetlights or traffic control systems, where the city already has conduit for easy access to twisted-pair cabling.

PLC

Power line communications can be used for streetlights, and some early projects pursued this technology because the existing power lines could then be used for communications without any change. The PLC approach is used by a few companies (Lumenia and gridComm). In PLC streetlight applications, RF is actually used in the majority of cases anyway. We don't expect a long term growth trend in the PLC format due to issues with transformers blocking the communications over longer distances.

802.15.4 ZIGBEE AND 802.15.4J

Zigbee devices can work via mesh topology, extending range in some cases for several miles. Of course, this topology relies on the presence of Zigbee nodes every 50-100 meters or so, but the obvious benefit is that there's no need for separate infrastructure on towers. One tradeoff of mesh networking is that battery life for meshed devices drops dramatically.

The Zigbee stack allows for very low power operation, and open reference designs from multiple companies makes a good environment for developers that want to tweak the Zigbee protocol in some way to suit their application.

The basic modulation format is offset-quadrature phase shift key, which allows asynchronous operation from multiple devices and maintains a low peak-to-average ratio for efficient amplifier operation. Zigbee can reach about 250 kbps in a 2 MHz channel, normally implemented in the sub-GHz ISM band.

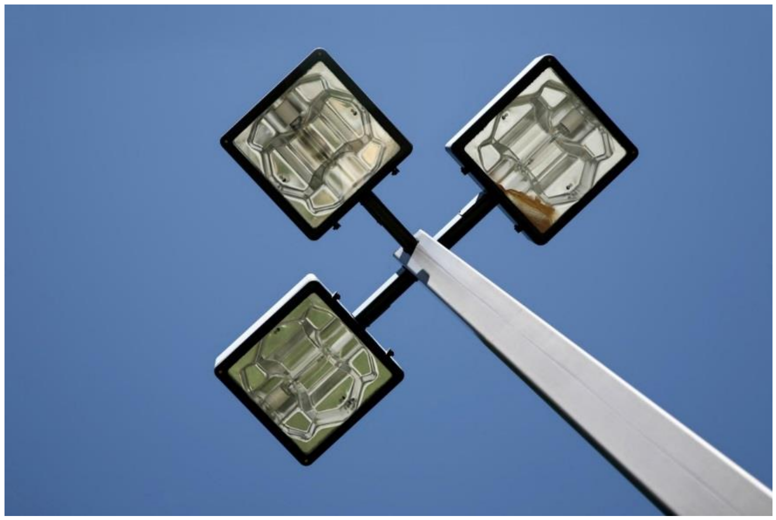

Figure 11 Streetlights using 802.15.4 based technology

Sources: Silver Spring

WI-FI

Wi-Fi is attractive because it's widely available in cities, but as an IoT connectivity standard Wi-Fi has problems with battery life and range of operation.

Wi-Fi is standardized by IEEE under 802.11, with releases now up to 802.11ac, 802.11ax, 802.11ay, among others with options from megabits per second up to gigabits per second. Unlicensed frequency bands are used at 2.4 and 5 GHz for relatively short-range communications. The Wi-Fi protocol has been popular for smart-home applications due to its ubiquitous coverage of homes, so products such as Nest thermostats and Roomba vacuum cleaners connect via Wi-Fi.

Wi-Fi is attractive to a city because—if a city has invested in municipal Wi-Fi—then the connectivity for their IoT solution is already in place. The City of San Jose has municipal Wi-Fi in the airport, so the BigBelly trash cans at the airport could connect through the existing network. This is actually not the case, as the Bigbelly product uses LTE connectivity and nobody wanted to redesign the trash-can connectivity to suit the local San Jose network.

In the end, the applications that are well suited to Wi-Fi include digital panels, information displays, and other city information that need adequate bandwidth for loading new graphics or video.

Figure 12   A Wi-Fi connected information display

Sources: ViewStation

LoRa:

LoRa (referring to the Long Range wireless protocol promoted by the LoRa Alliance) offers long-range connectivity with low cost and long battery life, and the open ecosystem of LoRa allows for operation in an ad hoc system without the intervention of a telecom operator. Cities don't like to depend on a mobile operator for a 40-year project related to streetlights, smart parking, or other infrastructure.   In this way, LoRa compares favorably with NB-IoT because it has similar characteristics but it works under a business model which is more compatible with systems owned by the city.

Figure 13 An example of a LoRa streetlight controller and gateway

Source: MingHui

TELENSA UNB (AND OTHER UNLICENSED LPWA)

Telensa has been quite successful in the streetlight market with their unlicensed Ultra Narrowband wireless format. Telensa UNB is a two-way format which uses the sub-1 GHz unlicensed band for a low cost, low bandwidth connection. Data rates in the range of 500 bps in the downlink and 62 bps in the uplink are specified in the UNB standard. Telensa's clear focus on the streetlight application have given this format a good start.

Sigfox, Ingenu, Weightless, and other Unlicensed LPWA formats have similar performance but are not found in many Smart City production devices, and we don't expect to see them as competitive solutions over the next ten years.

GSM, 3G, LTE, LTE-M:

These technologies use licensed frequencies ranging from 700 MHz to 2.6 GHz, generally with high power transmitters (up to 3W, or 250 mW for small devices). 3G and LTE standards are tailored for high data throughput, from 300 kbps up to 30 Mbps, but GSM technology is more suited to about 5-10 kbps with wide coverage in all locations.

Because of high power consumption, these radios are generally only used as a "backhaul" link for a gateway, not for sensors themselves that rely on long battery life.

LTE Category M changes the picture, as the latest release of LTE provides up to 1 Mbps of data over long range (3 miles or more) with low power consumption, opening up the possibility of connectivity in remote areas, or in buildings with enough bandwidth to handle voice connectivity.

In Smart City applications, devices that need higher levels of bandwidth (such as information displays, emergency call-boxes, and video cameras) tend to move into LTE. Some older applications are based on GSM or 3G, but those legacy standards are not used in new products because of their high power consumption, low bandwidth, and their doubtful future support at a network level.

LTE variations have the broad coverage and the bandwidth to support mobile voice applications and video upload/download from various devices. Cat-4 devices are generally enough for 5-10 Mbps anywhere in a well-covered city. Cat-1 devices are possible but are phasing out. Cat-M devices can reach about 1 Mbps outdoors, and at least 100 kbps (good enough for voice) indoors.

Figure 14 A surveillance camera using LTE connectivity

Source: Brickcom

NB-IoT:

LTE Category NB-1 (commonly called NB-IoT) is a narrowband variation of LTE communications with reduced bandwidth and greatly reduced power consumption. The range of NB-IoT connectivity can be as much as several miles, so this format has a good compromise of long battery life, long range, and low cost.

Technically, NB-IoT has a clear advantage over LoRa, with about 6 dB higher link budget margin to deal with attenuation from walls or other obstacles. NB-IoT has fairly good battery life characteristics, with comparable performance to LoRa and much better than cellular standards at LTE Cat-0 and above.

Huge adoption of NB-IoT in China has resulted in a rapid cost reduction curve, (assisted by some government R&D subsidies and additional device-level subsidies). Smart city applications are likely to move most significantly in China due to the intense government stimulus to move in this direction. Smart traffic solutions and smart streetlights are the main areas that fall into the scope of our "Smart City" category, although many other NB-IoT projects in China are related in areas such as smart metering, grid management, and asset tracking.

Figure 15 NB-IoT applied to smart streetlight connectivity

Source: China Telecom/Quectel video/Youtube

5G IoT:

As the 5G NR wireless format comes to market, many people are wondering whether the new technology will open up smart city and other IoT applications. So far, we don't see any significant impact coming from 5G for the smart city applications. While 5G technology can provide low latency (below 1 ms) as well as high capacity (1 Gbps or higher), today there's no demand for these attributes.

Applications such as smart streetlights, smart parking, and waste bins (the smart city applications with highest potential numbers of devices) simply do not need high capacity or low latency. Other applications involving surveillance video or traffic control may come a bit closer, but today we don't see volume in the millions for these applications. In the big picture, 5G technology really will not have much impact here.

5 OUTLOOK FOR SMART CITY IOT DEVICES

Worldwide, roughly 300 cities have launched Smart City projects (plus another 500-800 projects related to smart metering or other large-scale industrial projects, which we cover in separate reports). Many of these are considered "pilot" projects with only a few devices, but in some cases the numbers have reached tens of thousands.

In particular, streetlight projects have reached maturity in several cities, with replacement of about 3 million streetlights with LED upgrades that use IoT connectivity in 2017. (About 10 million have shipped over the past 10 years) Note that in the Mobile Experts forecast, we only count the IoT-connected streetlights, not simple LED upgrades—tens of millions of simpler LED upgrades are made each year.

Other applications are not as far along, with some thousands or tens of thousands of devices deployed so far.

The market potential is huge: roughly 320 million streetlights exist in the world, and 100 million urban parking spaces that are candidates for smart parking. (Note: some analysts count up to 5 billion parking spaces worldwide, but we consider only 2% of these to be "urban", with a rationale for smart-parking upgrade).

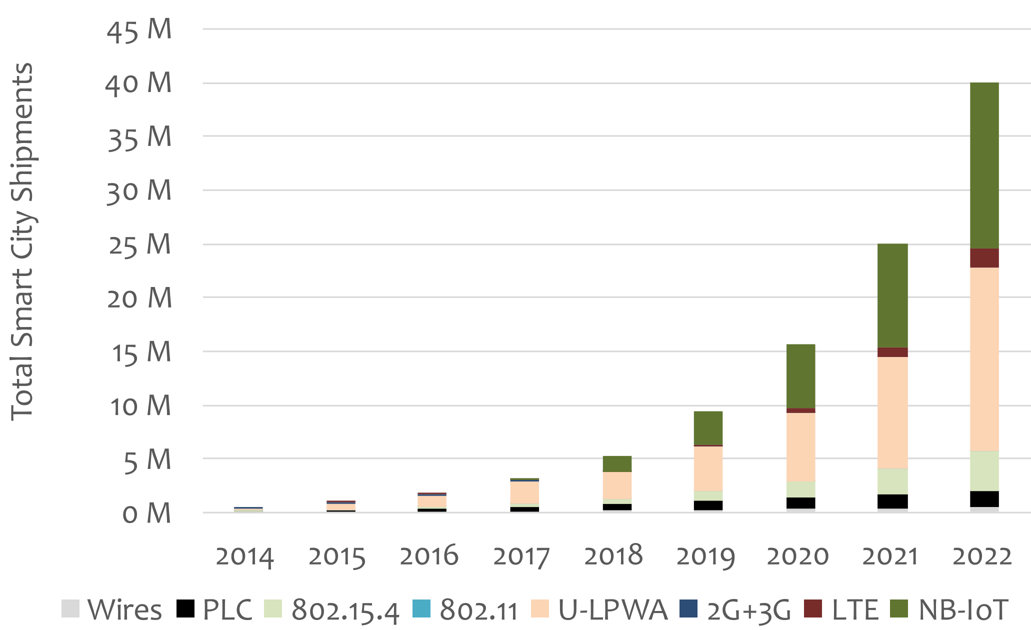

Chart 2: Overall Smart City Device shipments, by connectivity, 2014-2022

Source: Mobile Experts

Streetlights and parking dominate the forecast, as other applications in traffic control, transport, waste management, etc are smaller in total potential. A typical city-wide project might involve 50,000 streetlights, 30,000 parking spaces, 500 trash cans, 200 trains and buses, and so on.

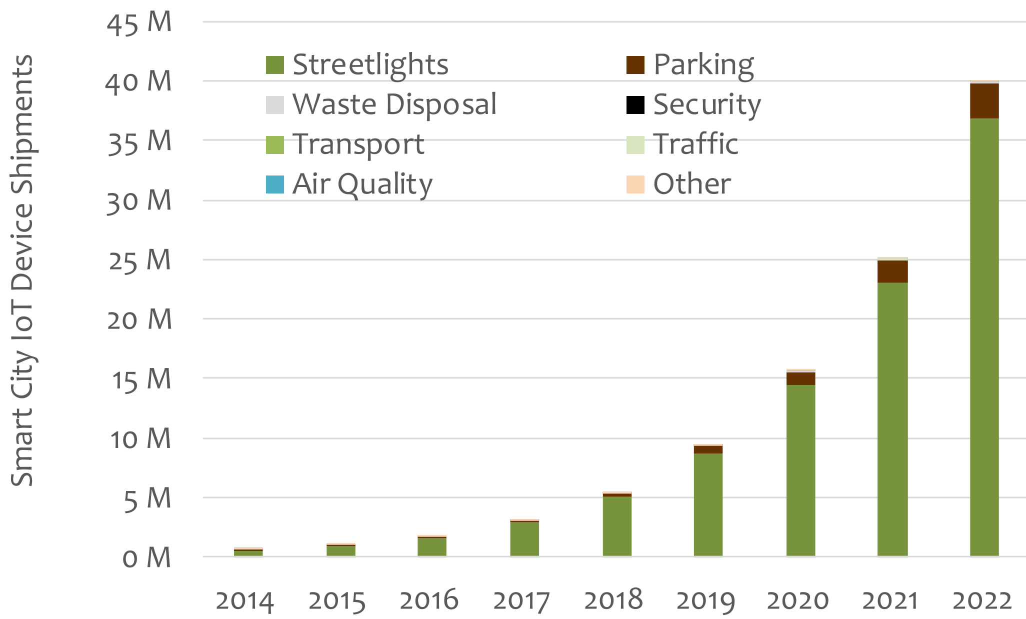

Chart 3: Overall Smart City Device shipments, by application, 2014-2022

Source: Mobile Experts

STREETLIGHT OUTLOOK:

The global opportunity is huge, as at least 320 million streetlights exist in the world, and very few have been connected with IoT-level automation. The installed base of connected streetlights has only reached a level of about 10 million units so far, with a fairly even mix of unlicensed LPWA, 802.15.4, and PLC technologies.

NB-IoT is coming on quickly, as the Chinese government is pushing massive projects to develop this technology within China. The government is offering subsidies on devices, directly and through the mobile operators, and the central government is putting pressure on local/city leaders to use NB-IoT in smart-city projects. For this single country, we expect a shift in the balance toward heavier use of 3GPP technology (namely NB-IoT) in streetlight projects.

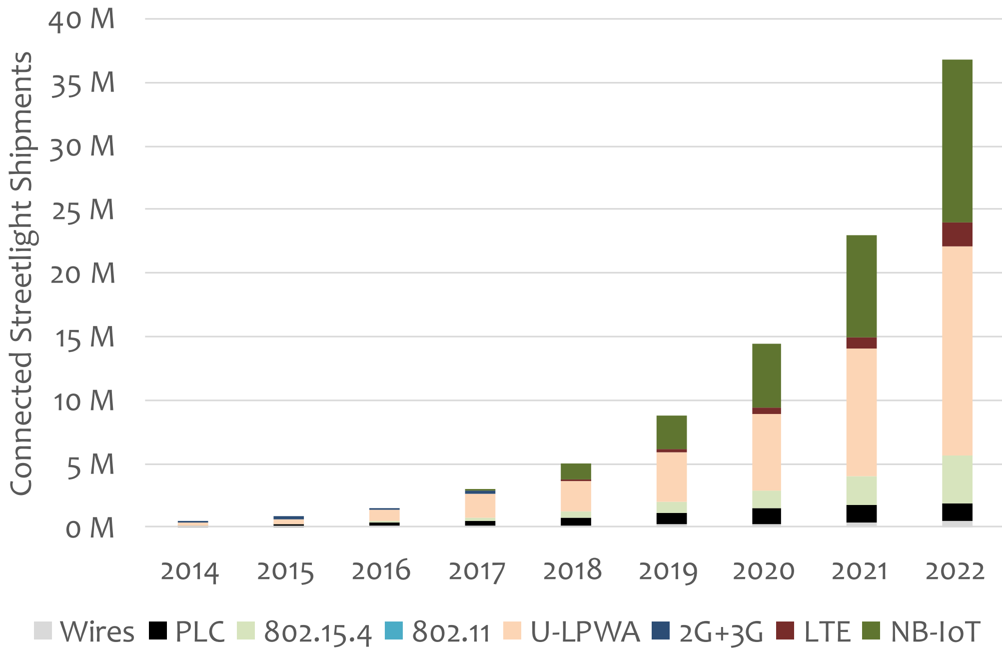

Chart 4: Connected Streetlight Shipments, by connectivity technology, 2014-2022

Source: Mobile Experts

SMART PARKING OUTLOOK:

With about 3-5 billion parking spaces on the planet, the potential is huge. But before we get too carried away, our investigation reveals that most of the parking spaces worldwide are obvious and easy to access. The number is much smaller for urban parking spaces that are difficult and expensive to access. We estimate that about 100 million parking spaces are "eligible" for an upgrade, meaning that they lie within the boundaries of a major city, are impacted with heavy occupancy, and cost more than $1 per day to access.

NB-IoT is coming for this market in China also, and in the case of smart parking the RF link budget advantages of NB-IoT will create value… it's a good choice for connectivity. We expect NB-IoT parking solutions to spread worldwide more than the streetlight example.

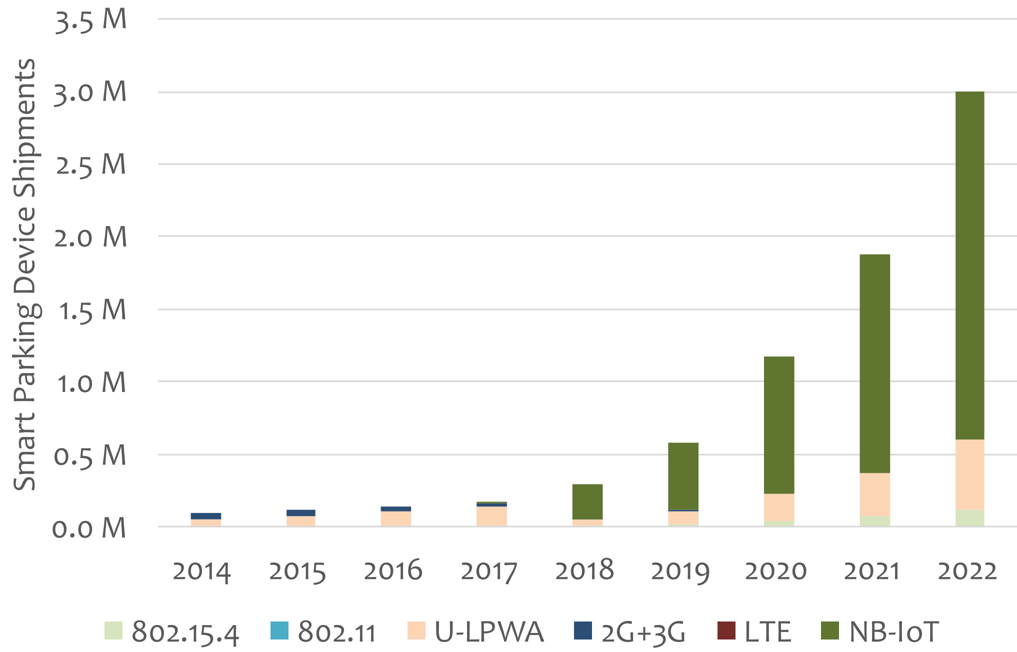

Chart 5: Smart Parking IoT Device Shipments, by technology, 2014-2022

Source: Mobile Experts

WASTE, SECURITY, TRAFFIC, TRANSPORT, AND OTHER IOT DEVICE OUTLOOK:

The other smart city applications will not reach the same volume as streetlights or parking, because the number of objects being connected is an order of magnitude smaller. The most promising applications are related to waste disposal and traffic control, where a few thousand sensors/devices are located in a major city. As an example, Los Angeles has about 5,000 traffic signals and a similar number of trash cans. But Los Angeles has about 2,000 buses and the number of trains is only about 100.

The ROI is also less clear in these applications, with more political benefits than economic benefits. A strong and sustained political movement for environmental improvement or traffic improvement could drive these projects, but that sort of initiative is local, not global. As a result we see slower growth for this segment of the market.

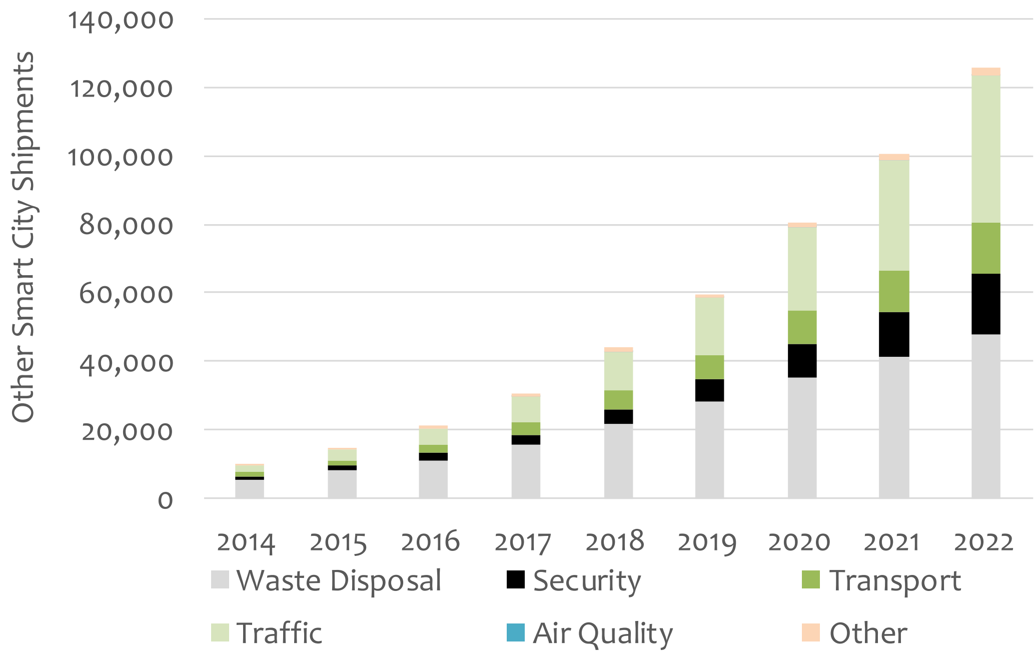

Chart 6: Waste, Security, Transport, Traffic, Air Quality Device Shipments, 2014-2022

Source: Mobile Experts

REGIONAL SMART CITY DEVICE OUTLOOK:

The United States and Europe have been good incubators for these technologies, as the liberal Western governments allow a local government to have enough freedom to initiate a new system or try a pilot program. However, we will see a minor shift toward China as their centrally controlled government pushes NB-IoT technology and subsidizes investments in smart-city projects.

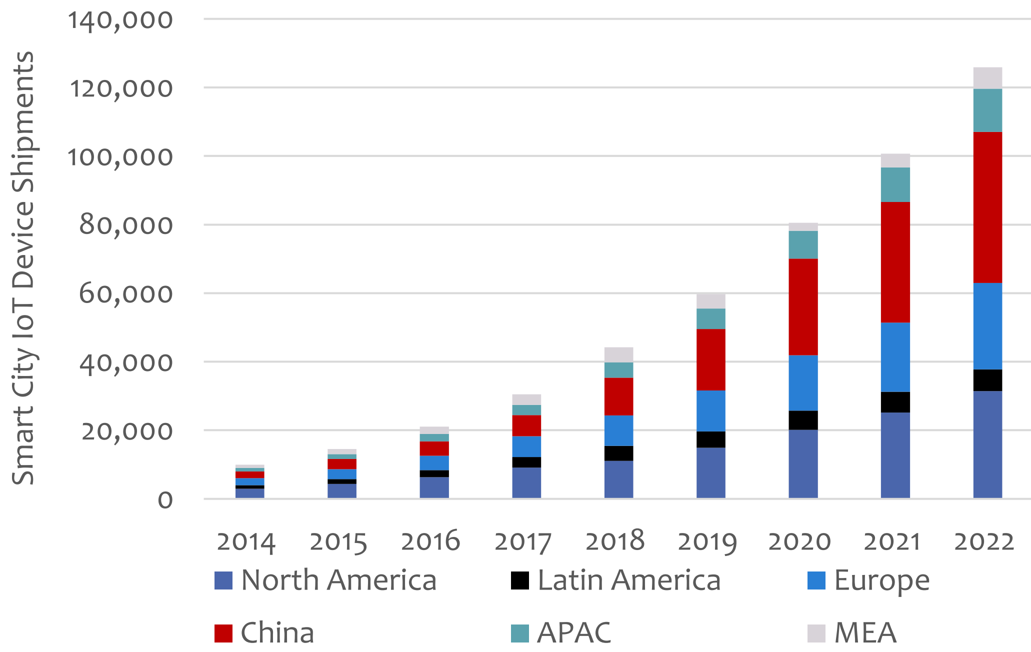

Chart 7: Global Smart City IoT Shipments, by region, 2014-2022

Source: Mobile Experts